

Recent Visit to Extrutech Manitowoc, WI

- Extrutech made panels used in ANL half-scale prototype
 - 34” wide; 34 cells, PVC with TiO₂
 - Cell cross section 2.5 cm x 4.1 cm
 - Similar to initial NOvA design
- We spoke with Greg Sheehy, president and founder
 - 3 hour non-stop meeting: Greg, Vic and RT
 - Q & A session about making NOvA extrusions
 - Asked for quotes for 5-cell and 32-cell dies
 - PVC composition & “color houses”
 - Extensive tour of the facility, with lots of technical detail
 - Bottom Line: NOvA profile (see drawing) is an excellent profile to extrude and black co-extrusion (cap) is no problem

The Facility

- Steel building 420ft x 235 ft x 24 ft
 - Outfitted cost: \$2.5M in 2001
- 17 extrusion lines, most are twin-screw
 - Most are high-end machines from Austria
 - Extruder, sizing, cooling, puller & saw
 - Room for two more lines, to be occupied soon
- Operates 24 hr shifts
- PVC only; no other material
- Very neat, impressive and efficient operation
- *All tooling is made in Austria or Italy*
 - “That’s where the best die-makers are”
 - Tooling is tested and tuned with the relevant PVC formula overseas
 - Production-ready tooling is shipped to Extrutech
- All PVC & Additives are provided by color houses
- Extrutech specializes in custom design





The Extrusion Process at Extrutech

- PVC powder is provided by color houses
 - Carolina Colors (7 year association)
 - Technon (recent association)
 - Aurora (“Arnold is one of best PVC/composition experts in the US”)
- Die, sizing and co-extrusion are made abroad
 - Primarily Austria
- We can expect ~ 1,000 lbs per hour production
- Expected tolerances, +/-
 - 10 mils along z (beam dimension)
 - 3 mils outside wall thickness
 - Flatness: will rest without gaps on flat pate
 - Banana
 - Left - Right balance of pvc flow in die is critical
 - The die will be balanced
 - The extrusion line will be built to keep extrusions straight

NOvA Profiles

Die can be built to accommodate co-extrusion tooling and can be used in either mode

- Quotes
 - 5-cell die with and without co-extrusion tooling
 - Quote expected today (~\$30k)
 - Time: 2 months to make die + 2 months testing/setup = 4 months
 - 32-cell die with and without co-extrusion tooling
 - Quote expected in a week (~\$200k)
 - Time: **6 months** to make die + 2 months testing/setup
- Co-extrusion thickness: experience with up to 20 mils
 - Could go thicker if necessary
 - Does not expect significant mixing of cap with reflective walls
- “Scallops” are optimal for this profile: excellent design
 - Keeps outer wall thickness constant
 - Inner dimensions (web) should be 30-40% thinner; they are
 - Harder to get heat out of the inner volume

Extrusion Line

Largest Extrusion Size now at Extrutech is 40”

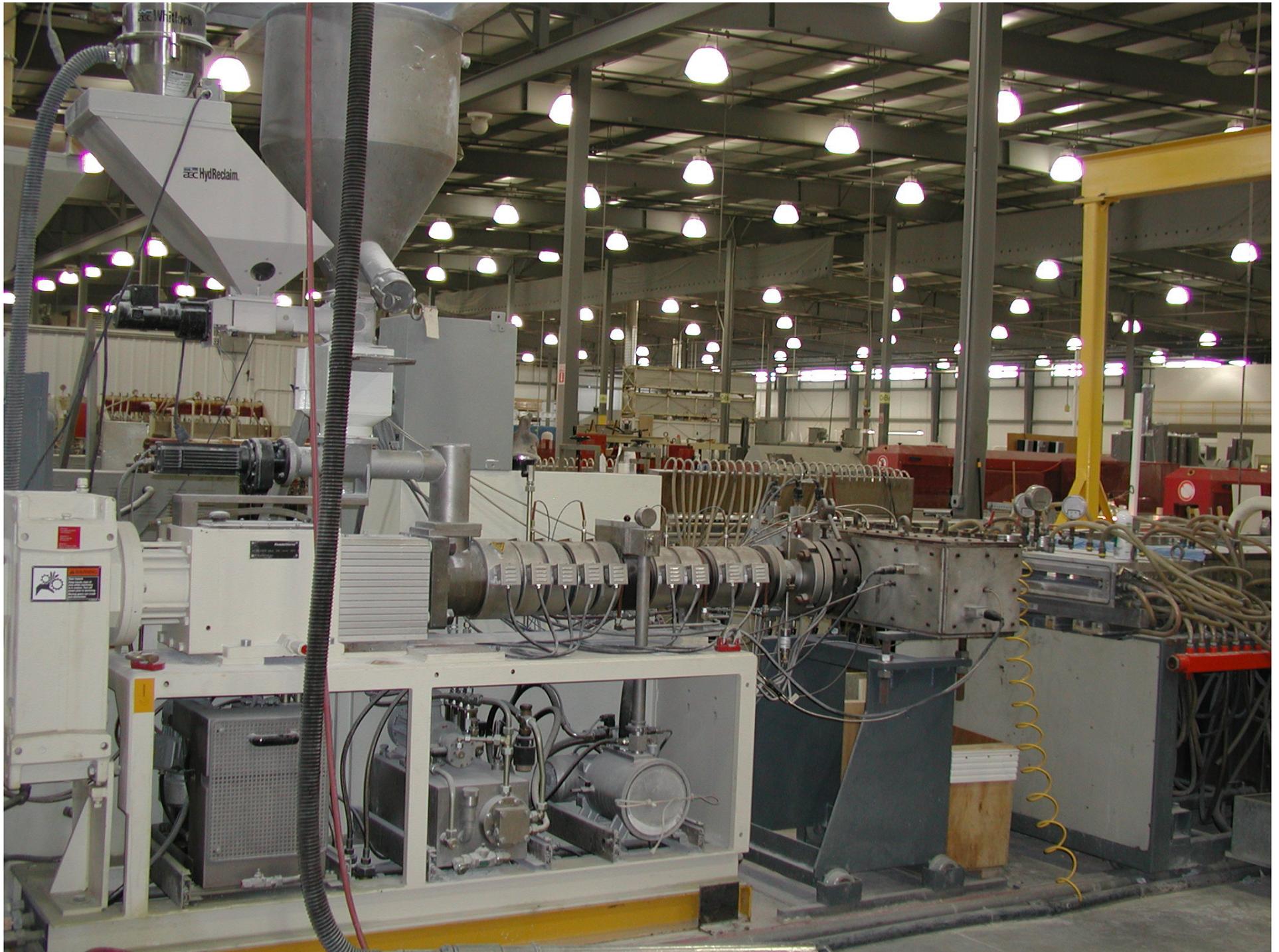
NOvA Extrusion is 51”

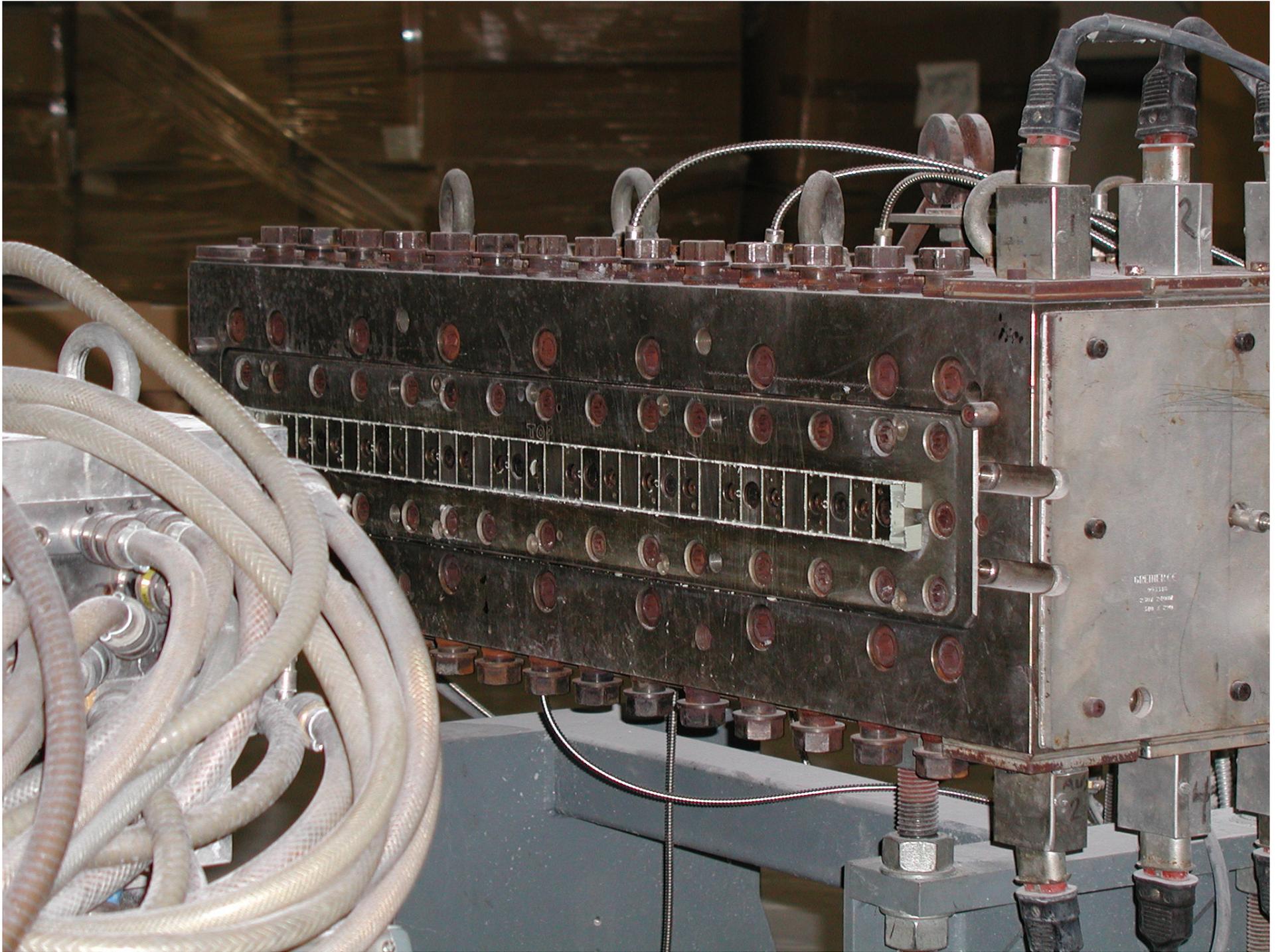
- Extruder (twin screw machine)
 - Vacuum feeder, hopper
 - 2 satellite extruders for black cap
- Die and co-extrusion tooling
- Sizing
 - Water cooled
 - vacuum suction to keep the shape
- Cooling
 - Water spray
 - Water bath
- Puller
- Saw

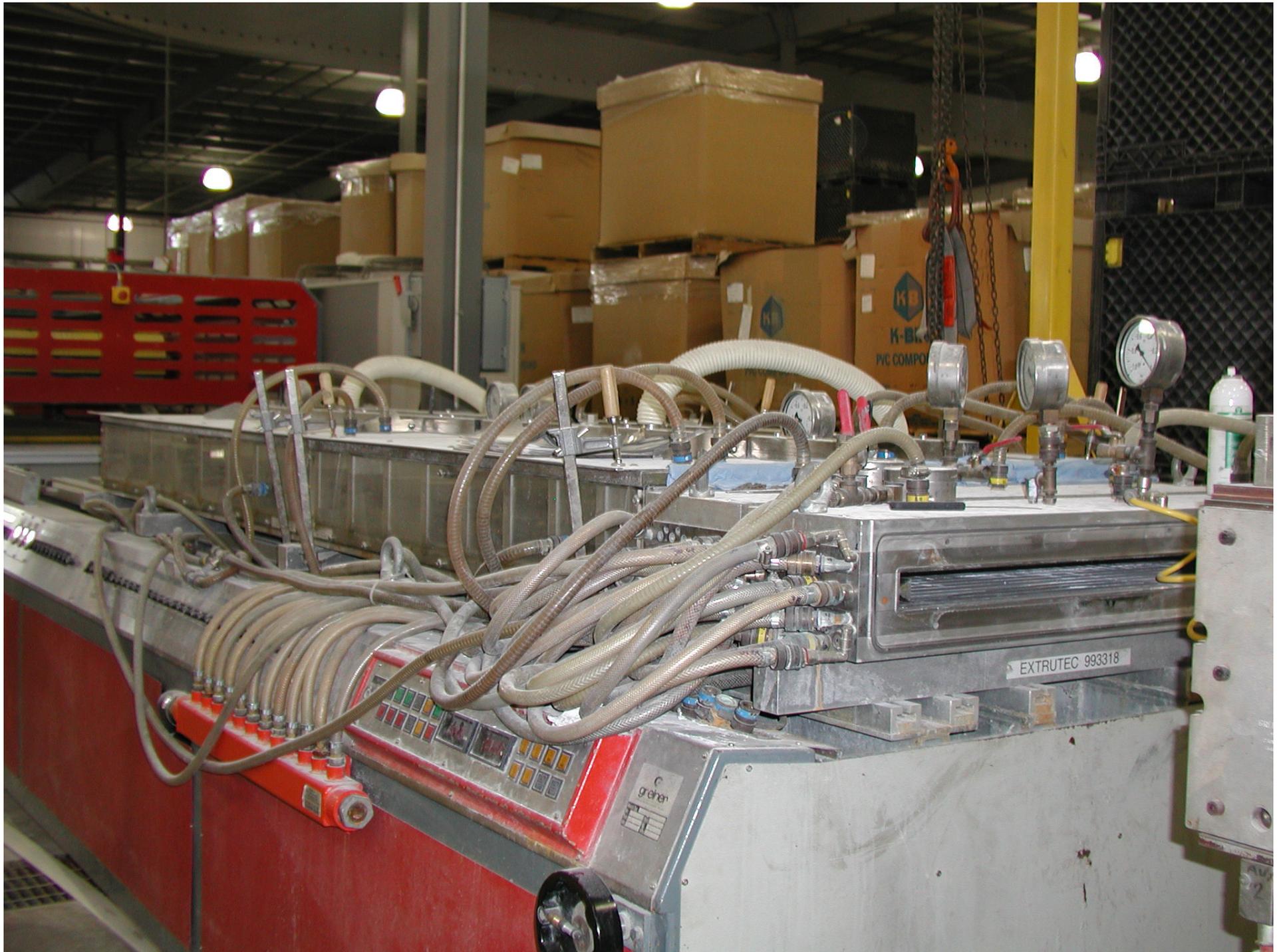
Can be used, but...
prefers to double power
for NOvA production

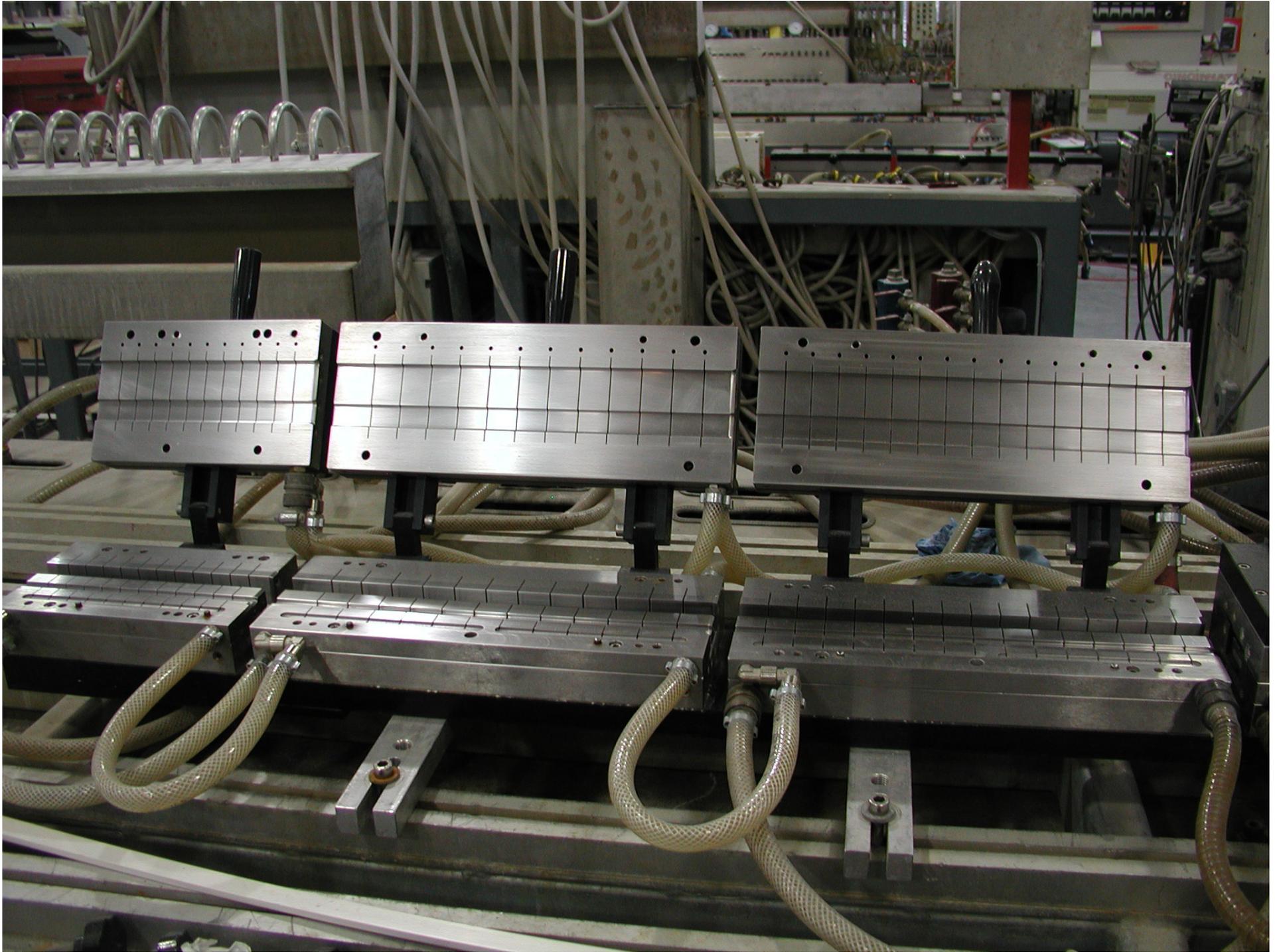
We purchase

Upgrade to larger size
Upgrade to larger size













Half-width Extrusions For Prototyping Cost Savings for R&D

- Don't make a 5-cell extrusion for \$30k
- Instead, make 16-cell extrusion for ~\$100k (my guess)
- We can learn a lot more from 16-cell than 5-cell
 - Build a FULL scale prototype, with twice as many extrusions
 - Verify that the NOvA detector can be built
 - ...is stable
 - ...can be instrumented and operated
- Cost for **full-size extrusion** production will be much more expensive if we want to produce only ~2-4% of NOvA extrusions for testing.
 - Save roughly \$200-\$300k by not going to full scale immediately
 - Later, ~\$100k will be small relative to final contract

General Impressions: They have a Vision

- Factory was planned very well
 - Linear flow; no constrictions
 - Rail line for raw materials
 - Space for 2nd building, adjacent
 - Lot for “color house”
- Plant is very clean, well-lighted and lightly-staffed
 - Highly automated
 - Backup power generator in event of power loss: Reduces cleanup!
- New product innovation by management is evident
- Use high quality machines and tooling
- Cost Estimate Factors
 - Production speed, size, type of material, quantity, etc. *to design an extrusion line specifically suited to the task.*
- In other words, don't base a contract decision on the cost of a die alone.





PRESSURE
SAW FEED



Misch Typ:	
1	2
3	4
5	6
7	8
9	10



